Red Eléctrica de España Uses Integer Programming for Annual Salary Revisions

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In this paper, we present a mixed-integer linear programming model for determining salary-revision matrices for an organization based on that organization's general strategies. The solution obtained from this model consists of salary increases for each employee; these increases consider the employee's professional performance, salary level relative to peers within the organization, and professional group. In addition to budget constraints, we modeled other elements typical of compensation systems, such as equity and justice. Red Eléctrica de España (REE), the transmission agent and operator of the Spanish electricity system, used the model to revise its 2010 and 2011 salary policies, and achieved results that were aligned with the company strategy. REE incorporated the model into the salary management module within its information system, and plans to continue to use the model in revisions of the module.

Keywords: mixed-integer linear programming; optimization; salaries; compensation policy; human resources.

Defining salary policies is one the most important elements of human resources management, because it has a profound impact on a company's overall performance and the motivation and performance of its employees. Consequently, this topic has attracted the attention of researchers (Hicks 1955, Elvira 2001, Coupe et al. 2006, Kwon et al. 2010, Bidwell 2011).

A compensation policy has three components: fixed salaries, bonuses, and benefits. This paper focuses on fixed salaries and their annual revision (i.e., determination of salary increases). A company revises the fixed salary of each employee based on elements such as merit, professional development, seniority, and cost of living. Salary-revision matrices are the most common approach to revising salaries (Jensen et al. 2007, Rowley and Jackson 2011). Such a matrix consists of a series of relative salary increases for groups of employees, where each cell in the matrix contains a value for a group of employees that share a set of features.

Salary-revision matrices are often embedded in performance-based compensation systems (Jensen et al. 2007), which also encompass variable-compensation management based on management-by-objective systems.

Performance-based compensation systems aim to improve overall organizational performance (Rowley and Jackson 2011) by

1. rewarding employees with high or very high levels of performance,
2. motivating all employees to attain a good level of performance, and
3. promoting planning and objectives setting.

Matrices may not be unique for all employees in a company but can be determined for different groups. For example, as we discuss in this paper, a common matrix may exist for all employees in a particular professional group.

Some studies (Jensen et al. 2007, Rowley and Jackson 2011) describe how to conceptually design salary-revision matrices; however, to our knowledge, no study describes the best practices applied by companies that make automatic computations to generate these matrices. Some authors describe processes to evaluate the matrices; these authors use experience, professional knowledge, and iterative simulations to determine values sufficient for the elements of the matrices (Arráiz 1999).

Our proposed method is efficient because it can be used to automatically generate matrices for large organizations using a set of precise criteria. Red Eléctrica de España (REE) reviewed, approved, and used matrices developed using this method to determine salary increases. The simplicity of the calculation strategy allows a company to perform multiple scenario evaluations to better align its compensation practices with changes in the labor environment. The literature does not include any systematic and reproducible approach to obtain these matrices; therefore, we cannot do any comparisons. We can say, however, that REE proved that the proposed model is valid, effective, and efficient.

REE demonstrated the validity of our approach by implementing the solution in its information systems and by its salary-revision experiences in 2010 and 2011. It met all REE requirements and provided an optimal solution that fit the company's strategy for awarding salary increases. In the current implementation, the model can be efficiently solved to optimality with the Excel solver in less than one second. REE has satisfactorily used the model since we developed it in 2010.

Although the literature does not describe any solution that effectively addresses this problem, REE has successfully applied a mixed-integer linear programming (MILP) model to solve it, thus motivating us to write this paper. To the best of our knowledge, no other practitioners have provided satisfactory approaches for determining these matrices.

We organized the rest of this paper as follows. First, we present the problem. We then present a case study based on our experience at REE, discuss the results of the model, and offer some final remarks that suggest how to extend the model to perform more complex analysis. The appendices contain the detailed formulation of the MILP model and the specific values of the input parameters we use in the case study.

Problem Description

In this section, we give an overview of the problem, provide a detailed description of its requirements, and discuss the objective we seek to attain.

Basic Problem Statement

The problem is to determine a salary increase (note that the salary increase can be zero) for each employee in an organization as a percentage of that employee's current salary. As we noted above, this is commonly done through salary-revision matrices.

In our solution, we aggregate employees into professional groups, use a different matrix for each group, and assess each employee based on performance, which is a factor in determining that employee's increase. Employees within the same professional group may earn different salaries. Therefore, we use percentiles to group employees according to their salaries in comparison to the other employees in the organization who have the same characteristics.

Our objective is to obtain a matrix G^g for each professional group g, where each element G^g_{ij} represents the salary increase of employees with a performance level i and a salary level j (see Table 1).

Requirements

The matrices to be determined must align with the organization's compensation policy. Therefore, we translate this into a set of requirements that the matrices must meet.

Total Budget. The total budget for salary increases is the sum of all budgets for all professional groups. The total increase for all employees in a professional

	Salary level 1	$\cdots$	Salary level j	$\cdots$	Salary level N
Performance level 1	G^g_{11}	$\cdots$	G^g_{1j}	$\cdots$	G^g_{1N}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
Performance level i	G^g_{i1}	$\cdots$	G^g_{ij}	$\cdots$	G^g_{iN}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
Performance level M	G^g_{M1}	$\cdots$	G^g_{Mj}	$\cdots$	G^g_{MN}

Table 1: The table illustrates a salary-revision matrix for a given professional group (g), which has N $(1, \ldots, N)$ salary levels and M $(1, \ldots, M)$ performance levels.

group cannot exceed that group's allocated budget. If each group meets this condition, the total salary increases will not exceed the organization's budget.

Maximum Increment. Relative salary increases cannot be larger than a specified value, which usually differs for each professional group.

Minimum Increment. Salary increases must be larger than a specified minimum value. The rationale behind this requirement is that companies want to maintain the motivating characteristic of salary increases, because giving a very low increase to each employee in the organization may not provide an incentive to any employee. This parameter reflects the level of differentiation of the compensation policy. A large minimum value means that fewer employees will receive salary increases.

Nonnegative Increments. We assume that salary increments are nonnegative; therefore, at worst, each employee maintains his (her) salary from one year to the next.

Equity. Salary increases are larger for employees with lower salary levels, provided all other conditions (e.g., professional group, performance level) are equal. The principle behind this requirement is that employees in the same professional group and at the same performance level should ultimately earn the same salary.

Justice. The salary increases are larger for employees with higher levels of performance, provided that all other conditions (e.g., professional group, salary level) are equal. Therefore, those employees who perform at a higher level tend to be better rewarded, although performance and salary levels are traded off based on the equity principle discussed above. For each professional group, we translate this into the following two ratios, which bound the salary increases.

- Ratio 1: The maximum allowed value for the ratio of salary increases for employees with given performance levels and that assigned to employees with higher performance levels, assuming they have the same salary level and belong to the same professional group.
- Ratio 2: The maximum allowed value for the ratio of salary increases for employees with given salary and performance levels and that for employees with higher salary and performance levels, assuming they belong to the same professional group.

Objective

Many matrices might meet the requirements previously stated; our objective is to find those matrices that largely satisfy a given goodness criterion. This criterion consists of maximizing the sum of salary increases for a set of employees with a higher priority, which represents maximizing the sum of a subset of the elements of all matrices, as defined above. Depending on the organizational policy, these elements may differ.

We also define a weighting coefficient for each cell within a matrix, such that all elements that contribute to the objective function do not contribute uniformly. For example, the organization may try to maximize salary increases for top-performing employees who are at the lowest salary level. Nevertheless, it may assign larger values for the weighting coefficient of higher (i.e., more qualified) professional groups, so that employees in these groups will receive relatively larger salary increases than employees in lower (i.e., less qualified) professional groups.

In Appendix A, we provide the MILP model formulation to determine salary increases and define its parameters. These values are of paramount importance; they reflect the company's strategy on rewarding employees while aligning this policy with its other policies. Next, we present a case study in which the values selected reflect a specific strategy.

REE Case Study

REE is responsible for the technical management of Spain's electrical system. It owns 99 percent of the Spanish high-voltage transmission network and is the only company in Spain that specializes in electrical energy transmission. REE is a private company and is quoted on the IBEX 35, which is the benchmark stock market index of the Bolsa de Madrid. In 2011, it employed 1,600 highly qualified professionals, more than two-thirds of whom are university graduates. The main objectives of its human resources policy are to motivate employees, ensure that they have a high level of commitment to the organization, and provide them with opportunities for enriched professional careers. REE first applied the MILP model to determine salary-revision matrices in 2010 (to determine 2011 salaries).

Input Data

Our REE case study included 1,149 employees in four professional groups: A is the lowest professional level, B and C are medium levels, and D is the highest level. Five salary levels correspond to four quartiles (Q1–Q4) and an out-of-range (OR) level for employees whose salaries are far above the average of their peers. Finally, we considered five performance levels (1–5), where 1 represents the lowest evaluation level and 5 represents the highest level. Therefore, our objective was to obtain four 5×5 salary matrices (i.e., 100 values) for each employee in the company. Table 2 summarizes the number of employees grouped based on professional group and salary level.

For confidentiality reasons, we cannot reveal actual salaries; therefore, we applied an affine transformation to them. Table 3 summarizes the resulting values, which we use in the remainder of this paper. This table shows the average values for all employees—for all performance levels, professional groups, and salary levels. The suggested policy in this example differs sufficiently from REE's actual policy to ensure that we reveal no confidential information.

	Q1	Q2	Q3	Q4	OR	Total
Group A	12	52	21	3	27	115
Group B	118	121	25	0	4	268
Group C	261	105	22	2	24	414
Group D	171	99	36	2	44	352
Total	562	377	104	7	99	1,149

Table 2: The table shows the number of REE employees in each professional group (A, B, C, and D) and salary level (Q1, Q2, Q3, Q4, and OR). For example, 105 employees are in professional group C at salary level Q2.

	Q1 ($)	Q2 ($)	Q3 ($)	Q4 ($)	OR ($)
Group A	235	256	277	295	319
Group B	292	313	344	364	372
Group C	337	369	400	422	461
Group D	400	448	492	507	579

Table 3: The table shows the average salary of REE employees in each professional group at each salary level.

Implementation

We developed the first prototype of the model using the Excel solver on a standard desktop computer and achieved good results. For research and development purposes, we then implemented the model using AIMMS 3.12 (Roelofs and Bisschop 2011) in combination with CPLEX (ILOG 2008). Although the results obtained were identical, the AIMMS–CPLEX environment offered us more functionality to exploit information and introduce additional elements into the model. REE deployed all its human resources management processes into SAP, its enterprise resource program; these processes include employee management, payroll, recruiting, training, professional development, assessment, and compensation. This implementation of compensation management comprised salary band, individual salary management and analysis, and annual salary reviews.

Since 2001, the REE salary-review process has used matrices that the human resources staff designed manually; however, updating these matrices required several weeks. In 2011, the company decided to implement the algorithm we describe in this paper to enable its human resources staff to easily evaluate multiple salary-review scenarios to increase the efficiency of this process.

To integrate this algorithm into the SAP management system, the team that implemented the algorithm within the human resources management software decided to simplify it by not considering the minimum-salary-increase constraint. Instead, it applied this constraint after generating the matrix; however, this simplification caused small imbalances in the budget application. This approximation was adequate because it provided matrices that could be tuned slightly during the salary-review process, in which line managers updated the proposals generated for the salary reviews and then considered this budget imbalance in this final adjustment. REE currently uses this process to address the minimum-salary-increase constraint.

Because of this simplification, REE could use the simplex implementation available within the Commons Math 2.2 Java library (http://commons.apache.org/math, accessed July 2012). Each algorithm parameter was stored in a table and passed to the Java module in which the algorithm runs. The results were then passed back to SAP and stored in tables.

REE used the results of implementing the algorithm to revise its 2010 and 2011 salaries to determine 2011 and 2012 salaries, respectively; the results it achieved were viewed positively by both employees and managers. Its information systems are now ready to support the process for obtaining new salary matrices, as we explain later.

The users (i.e., human resources personnel) set all the parameters in a graphical user interface developed ad hoc for this purpose. These experts set the parameters; solved the model; and analyzed, validated, and approved the salary-review proposal. It was then given to the line management for revision and approval. Line managers could adjust it to satisfy both the original budget constraint and company policies relative to justice and equity.

As a final step, a corporate calibration panel, composed of all REE's managing directors, reviewed and approved the proposal that the line managers revised.

Results

The model permits an assessment of multiple policies based on parameter values. For example, if REE is primarily interested in enhancing the level of internal equity, the parameters entered into the model could be set accordingly. In particular, this would consist of providing the model with input data to ensure that it allocates a larger proportion of the budget to those employees with high performance levels and low salaries (i.e., levels Q1 and Q2). Next, we describe the elements on which that strategy relies; Appendix B provides additional details (see Tables B.1 and B.2).

- Total budget: We set this as a portion (i.e., 1.6 percent) of the total personnel cost for 2011.
- Budget splitting across professional groups: To professional group C, we assigned 90 percent of the amount assigned to group D; to each of groups B and A, we assigned 40 percent of the amount assigned to group D.
- Maximum and minimum increases for each professional group: The highest maximum increase (10 percent) was given to employees in professional group D; the minimum increase given to employees in groups B and A was four percent. Minimum increases were consistent with the values historically used by REE before it implemented this model: three percent for group D employees and 1.20 percent for employees in each of groups B and A.
- Justice parameters: These parameters refer to the maximum ratios as described in the *Requirements* section. We set these values to 100 percent for all professional groups.
- Internal equity parameters (i.e., the equity ratio described above in the *Requirements* section): We set these parameters to 70 percent for all professional groups.
- Preferences: Employees at specific combinations of salary and performance levels received higher compensation percentages. Appendix B shows the corresponding values. Employees with salary levels in Q1, performance levels of 4 and 5, and coefficients equal to 1 were considered to merit relatively higher salary increases than other employees. Employees with performance levels of 1 and coefficients equal to 0 were considered to merit relatively lower (or no) salary increases; the optimization model was designed to avoid solutions by which these employees would receive salary increases. The other groups of employees received increases consistent with the values of their coefficients—larger or equal to 0 and smaller than 1.

Tables 4, 5, 6, and 7, respectively, show the salary matrices for professional groups A, B, C, and D.

	Q1	Q2	Q3	Q4	OR
Level 1					
Level 2	1.37				
Level 3	1.96	1.37			
Level 4	2.80	1.96	1.37		
Level 5	4.00	2.80	1.96	1.37	

Table 4: The salary percentage increases for REE employees in professional group A are categorized based on performance level (1–5) and salary level (Q1, Q2, Q3, Q4, and OR). Empty cells correspond to employees who will not receive a salary increase.

	Q1	Q2	Q3	Q4	OR
Level 1					
Level 2					
Level 3	1.20				
Level 4	2.80	1.61			
Level 5	4.00	2.80	1.96	1.37	

Table 5: The salary percentage increases for REE employees in professional group B are categorized based on performance level (1–5) and salary level (Q1, Q2, Q3, Q4, and OR). Empty cells correspond to employees who will not receive a salary increase.

	Q1	Q2	Q3	Q4	OR
Level 1					
Level 2					
Level 3					
Level 4	6.30	4.41	3.09		
Level 5	9.00	6.30	4.41	3.09	

Table 6: The salary percentage increases for REE employees in professional group C are categorized based on performance level (1–5) and salary level (Q1, Q2, Q3, Q4, and OR). Empty cells correspond to employees who will not receive a salary increase.

	Q1	Q2	Q3	Q4	OR
Level 1					
Level 2					
Level 3					
Level 4	6.76				
Level 5	10.00	7.00	4.90	3.43	

Table 7: The salary percentage increases for REE employees in professional group D are categorized according to performance level (1–5) and salary level (Q1, Q2, Q3, Q4, and OR). Empty cells correspond to employees who will not receive a salary increase.

	Budget ($)	Allocated salary increase ($)	Unallocated budget ($)	Budget usage (%)	Differentiation level (%)
Group A	249.08	224.43	24.65	90.1	49
Group B	658.15	658.15	0.00	100.0	50
Group C	2,649.39	2,522.67	126.72	95.2	31
Group D	3,133.40	3,133.40		100.0	30
Total	6,690.02	6,538.65	151.37	97.7	37

Table 8: For each professional group (row), the table shows how the available budget (first column) for that group has been allocated. In particular, the "Allocated salary increase" and "Unallocated budget" columns are, respectively, the amounts that will and will not be allocated; "Budget usage" is the portion of the available budget that has been allocated; and "Differentiation level" is the percentage of employees who will not receive a salary increase.

	Level 1	Level 2	Level 3	Level 4	Level 5	Total
Group A	0	5	67	64	20	49
Group B	0	0	49	83	100	50
Group C	0	0	0	97	93	31
Group D	0	0	0	42	92	30
Total	0	1	21	79	89	37

Table 9: The numbers in the table represent the percentages of employees who will receive a salary increase categorized by professional group (row) and performance level (column).

	Level 1	Level 2	Level 3	Level 4	Level 5	Total
Group A	0.0	0.1	1.0	1.2	0.6	0.8
Group B	0.0	0.0	0.6	1.7	2.8	0.8
Group C	0.0	0.0	0.0	5.3	6.2	1.7
Group D	0.0	0.0	0.0	2.8	7.2	2.1
Total	0.0	0.0	0.3	3.4	6.0	1.6

Table 10: The table shows the percentages of the average salary increases for employees in each professional group (row) and performance level (column).

In this case study, our objective was to allocate budget increases so that those employees with the same performance levels would earn the same salary over time. To achieve this objective, employees with lower salary levels and higher performance levels would receive higher percentages of increases more than other groups.

The resulting matrices (Tables 4–7) reflect the policy selected. Tables 8–10 summarize the overall results of the salary revisions provided by the model. Note that a relatively large number of employees have low salary levels and will be better rewarded. In fact, 37 percent of the employees will receive some salary increase—a number that is higher than it would have been if the equity principle had been less relevant. Only 2.3 percent of the available budget was not allocated.

The model is designed to reduce the salary gap between employees who have the same performance levels but different salary levels. Therefore, values of the model parameters can be selected such that employees with out-of-range salary levels will consistently not receive any salary increases—no matter how high their performance levels are. Only 89 percent of employees with the highest performance level (level 5) will receive a salary increase; however, 79 percent of employees with performance level 4 will receive a salary increase because of their relatively low salary levels.

Conclusions

The model for determining matrices for salary revisions we present in this paper allows an organization to determine its salary strategies in a flexible, reliable, and easily implementable way. The major contribution of this work is the mathematical formulation of the criteria that are typically the basis for salary management. The compact formulation and the ease of obtaining the optimal solution facilitate its use in large companies that maintain very high levels of homogeneity across employees. Designing different strategies for specific groups within a company is also possible.

A major benefit of this method is that it allows a company to independently manage its salary and assessment policies. Because obtaining salary-revision matrices without using the mathematical model we present in this paper is typically done iteratively by tuning previously defined matrices, managers commonly tune values for assessing employee performance to ensure that salary increases and performance assessments are consistent; however, this distorts the evaluation process and decreases employee motivation. In our MILP model, employee performance is only one parameter of several input parameters used in designing a salary policy that is independent of the results of performance-assessment values.

A future enhancement to this model could extend it so that different matrices are obtained for different units or divisions within the company to smooth the effect of manager bias in employee evaluations. This would provide a higher level of internal equity and feedback for periodic performance assessment while promoting higher levels of performance-assessment differentiation.

Appendix A. MILP Model

Index Sets

$\mathcal{G}$: All professional groups; the higher the index of an element in this set, the higher the level of the professional group.

$\mathcal{P}$: All performance levels; the higher the index of an element in this set, the higher the level of performance of the corresponding employee.

$\mathcal{S}$: All salary levels; the higher the index of an element in this set, the higher the level of the salary level.

Any parameter, variable, or constraint running on the elements of $\mathcal{S}$ refers to the process that REE employed before it used our model to determine salary increases.

Parameters

B: Total budget.

B_g: Relative budget assigned to professional group $g \in \mathcal{G}$ as a proportion of the budget allocated to the highest professional level ($0 \leq B_g \leq 1$).

SG_{gs}: Current average salary of employees with salary level $s \in \mathcal{S}$ within professional group $g \in \mathcal{G}$.

N_{gps}: Number of employees in $g \in \mathcal{G}$ with salary level $s \in \mathcal{S}$ and performance level $p \in \mathcal{P}$.

U_g: Maximum relative salary increase for employees in group $g \in \mathcal{G}$.

L_g: Minimum relative salary increase for employees in group $g \in \mathcal{G}$.

EQ_g: Maximum value for the ratio between the relative salary increase for employees with a given salary level and employees with a lower salary level and the same performance level, all in professional group $g \in \mathcal{G}$ ($0 < EQ_g \leq 1$).

J_g: Maximum value for the ratio between the relative salary increase for employees in group $g \in \mathcal{G}$ with the same salary level and the employees in the same group with the same salary level and higher performance levels ($0 < J_g \leq 1$).

K_g: Maximum value for the ratio between the relative salary increase for employees with a given salary and performance level and the relative salary increase with a higher salary and performance level, all in professional group $g \in \mathcal{G}$ ($0 < K_g \leq 1$).

A_{gps}: Objective differentiating coefficient for professional group $g \in \mathcal{G}$, performance level $p \in \mathcal{P}$, and salary level $s \in \mathcal{S}$.

We can define an additional parameter, which is the absolute budget corresponding to each professional group $g \in \mathcal{G}$:

$$BP_g = B\frac{B_g \sum_{s\in\mathcal{S}}(SG_{gs} \sum_{p\in\mathcal{P}} N_{gps})}{\sum_{g\in\mathcal{G}} B_g \sum_{s\in\mathcal{S}}(SG_{gs} \sum_{p\in\mathcal{P}} N_{gps})}. \tag{A1}$$

We can easily check that $\sum_{g\in\mathcal{G}} BP_g = B$, so that by assigning values to B_g, the total budget will be split among all professional groups.

Decision Variables

y_{gps}: 1 if employees in professional group $g \in \mathcal{G}$, at performance level $p \in \mathcal{P}$, and at salary level $s \in \mathcal{S}$ will receive a salary increase, 0 otherwise.

x_{gps}: Relative salary increase for employees in professional group $g \in \mathcal{G}$, at performance level $p \in \mathcal{P}$, and at salary level $s \in \mathcal{S}$.

Model Formulation

$$\text{maximize} \quad \sum_{g\in\mathcal{G}}\sum_{s\in\mathcal{S}}\sum_{p\in\mathcal{P}} A_{gps}x_{gps} \tag{A2}$$

$$\text{s.t.} \quad \sum_{s\in\mathcal{S}} SG_{gs} \sum_{p\in\mathcal{P}} N_{gps}x_{gps} \leq BP_g \quad g \in \mathcal{G}; \tag{A3}$$

$$x_{gps} \leq U_g y_{gps} \quad g \in \mathcal{G}, p \in \mathcal{P}, s \in \mathcal{S}; \tag{A4}$$

$$x_{gps} \geq L_g y_{gps} \quad g \in \mathcal{G}, p \in \mathcal{P}, s \in \mathcal{S}; \tag{A5}$$

$$x_{gps} \leq EQ_g x_{gps-1} \quad g \in \mathcal{G}, p \in \mathcal{P}, s \in \mathcal{S}; \tag{A6}$$

$$x_{gps} \leq J_g x_{gp+1s} \quad g \in \mathcal{G}, p \in \mathcal{P}, s \in \mathcal{S}; \tag{A7}$$

$$x_{gps} \leq K_g x_{gp+1s+1} \quad g \in \mathcal{G}, p \in \mathcal{P}, s \in \mathcal{S}; \tag{A8}$$

$$y_{gps} \in \{0,1\} \quad g \in \mathcal{G}, p \in \mathcal{P}, s \in \mathcal{S}; \tag{A9}$$

$$x_{gps} \geq 0 \quad g \in \mathcal{G}, p \in \mathcal{P}, s \in \mathcal{S}. \tag{A10}$$

Equation (A2) is the objective function, where the values of the salary increases for each set of employees sharing a professional group, performance level, and salary level are considered, such that these sets are given different relative importance in accordance with the company policy. Equation (A3) provides the upper bound for the amount of allocated budget to a particular professional group, as defined by the managers. Equations (A4) and (A5) provide the upper and lower bounds for the salary increases, respectively, such that very small or very large values are not allowed. Equation (A6) is the implementation of the equity criterion; Equations (A7) and (A8) are the implementation of the justice criterion. Finally, Equations (A9) and (A10) are the dominion constraints for the problem variables.

Appendix B. Case Study Values

The elements of the sets for the case study are as follows:

$$\mathcal{G} = \{A, B, C, D\},$$

$$\mathcal{P} = \{1, 2, 3, 5\},$$

$$\mathcal{S} = \{Q1, Q2, Q3, Q4, OR\}.$$

g	U_g	L_g	J_g	K_g	EQ_g	B_g
Group A	4.00	1.20	100.00	100.00	70.00	0.40
Group B	4.00	1.20	100.00	100.00	70.00	0.40
Group C	9.00	2.70	100.00	100.00	70.00	0.90
Group D	10.00	3.00	100.00	100.00	70.00	1.00

Table B.1: The parameter values for each professional group correspond to the percentages of maximum and minimum salary increases (U_g and L_g), justice and equity parameters (J_g, K_g, and EQ_g), and the available budget (B_g).

	Q1	Q2	Q3	Q4	OR
Level 1	0	0	0	0	0
Level 2	0.3	0.1	0	0	0
Level 3	0.9	0.3	0.1	0.1	0
Level 4	1	0.6	0.3	0.1	0.1
Level 5	1	0.8	0.6	0.3	0.1

Table B.2: The values for the differentiating coefficients for the policy corresponding to the policy evaluated represent the relative weight that a particular set of employees who share a performance level (row) and salary level (column) will have when allocating the available budget (A_{gps}).

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Verification Letter

José García Moreno, Human Resources (HR) Director of Red Eléctrica de España, Paseo del Conde de los Gaitanes, 177, 28109 Alcobendas, Madrid, Spain, writes:

"Red Eléctrica de España (REE), the Spanish Electricity Transmission and System Operator, has implemented the Mixed Integer Programming (MIP) Model for obtaining the salary revision matrices in its HR management systems. This MIP model has been successfully implemented and tested in 2011, and it is integrated since then in our compensation and benefits management systems.

"One of the most valuable benefits obtained from this model is the ability to separate the salary revision process from the performance evaluation one to improve the accuracy of the evaluation systems. This MIP model allows our organisation to execute a faster, more efficient and effective determination of the salary revision proposal for our employees.

"The performance and outputs of the MIP model fulfil our organisation requirements, which also takes into account our Human Resources Compensation Policies, budget constraints and organisational structure."

Ángel Mahou is the chief information officer of Red Eléctrica de España (REE). He previously served as the head of the HR Development Department at REE, where he has worked since 1990. He obtained his degree in industrial engineering and an MSc in production organization from the Higher Technical School of Industrial Engineering, Technical University of Madrid in Spain. His research interests are simulation and optimization for production, organization of work, and human resources.

Álvaro García-Sánchez is a professor at the Higher Technical School of Industrial Engineering, Technical University of Madrid (UPM) in Spain. He obtained his degree in industrial

engineering and his PhD from this same university. His main areas of interest are simulation and optimization for production and logistics. He lectures in graduate, postgraduate, and PhD courses at UPM and used to coordinate the master's and PhD programs in industrial engineering ("Ingeniería de Organización"). He also collaborates with other universities and offers training for companies. In addition, he has a close contact with the practitioners' world as he carries on consulting activities, which led him to set up a company in 2011, making the best of the synergies derived his consulting and academic activities.

Miguel Ortega-Mier is a teacher and researcher at the Department of Industrial Engineering, Business Administration and Statistics, Technical University of Madrid (UPM). He holds a PhD in industrial engineering from UPM. His research interests are optimization and event discrete simulation; he is also founder of baobab soluciones, a UPM spin-off company based in these areas. He has published several articles in international journals. His website address is http://www.iol.etsii.upm.es/mom.html.

Ana Moreno Romero is an associate professor in the Industrial's Organization Unit at the Technical University of Madrid (UPM) and a postgraduate lecturer and coach. She received her degree in industrial engineering from the Higher Technical School of Industrial Engineering at UPM and her PhD in social and organizatonal psychology from the Universidad Nacional de Educacaión a Distancia. Her areas of interest include organization of work and human resources, corporate social responsibility, and networked organizations. Before her current position, she was partner and founder of the ENRED Consultores Information Society area (1995–2007) and worked at IBM (1989–1995).